STUDY ON COMPARISON OF THREE METHODS OF GRADUAL WEANING FROM MECHANICAL VENTILATORS

Dissertation submitted for

MD DEGREE EXAMINATION
BRANCH VII – PEDIATRIC MEDICINE

INSTITUTE OF CHILD HEALTH AND HOSPITAL FOR CHILDREN
MADRAS MEDICAL COLLEGE
THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY
CHENNAI

APRIL 2011

CERTIFICATE

This is to certify that the dissertation titled **"STUDY ON COMPARISON OF THREE METHODS OF GRADUAL WEANING FROM MECHANICAL VENTILATORS"** submitted by Dr. P. BHARATHI to the faculty of pediatrics, the Tamilnadu Dr. M.G.R. Medical university, Chennai in partial fulfillment of the requirement for the award of M.D. Degree (pediatrics) is a bonafide research work carried out by her under our direct supervision and guidance.

Dr.J.MOHANASUN DARAM
M.D.,Phd.,DNB,
Dean,
Madras medical college,
Chennai - 3

Dr. P. RAMACHANDRAN
M.D., DNB
Director & superintendent,
Institute of child health &
Hospital for children,
Egmore, Chennai - 8

Prof. Dr. P.S. MURALIDHARAN
M.D.,DCH
Prof. of pediatrics,
M III unit, ICH & HC

Prof. Dr. P. JAYACHANDRAN
M.D.,DCH
Prof. of pediatrics
PICU, ICH & HC

DECLARATION

I. DR.P.BHARATHI solemnly declare that the dissertation titled **"STUDY ON COMPARISON OF THREE METHODS OF GRADUAL WEANING FROM MECHANICAL VENTILATORS"** has been prepared by me. This is submitted to **The Tamilnadu Dr.M.G.R. Medical University,** Chennai in partial fulfillment of the rules and regulations for the M.D. Degree Examination in Pediatrics.

Place :
Date :

Dr. P.BHARATHI
Chennai

SPECIAL ACKNOWLEDGEMENT

My sincere thanks to prof. Dr. Mohana sundaram M.D.,DNB.,Phd the Dean, Madras medical college, for allowing me to do this dissertation and utilize the institutional facilities.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Prof. Dr. P. Ramachandran, M.D., DNB , director and superintendent of Institute of child health and hospital for children for permitting me to undertake this study and for his guidance, invaluable help, encouragement and support throughout the study.

I am extremely thankful to Prof. Dr. P.S. Muralidharan M.D., DCH , my unit chief for his guidance , invaluable and timely help , encouragement and support throughout the study.

I would like to thank Prof. Dr. P. Jayachandran M.D.,DCH , Chief, Pediatric intensive care unit, Dr. S. Shanthi, M.D., DCH., Dr. V. Poovazhagi, M.D., Dr. Ezhilarasu, M.D., Dr. Sivaraman M.D., Asst. Professors , PICU for their meticulous guidance and support throughout the study. Special thanks to Dr. S. Thangavelu, M.D., DCH.,MRCP., Former reader , PICU who motivated me to take up this study.

I am extremely thankful to Dr. srinivasan DCH., Registrar,

for his valuable suggestions, invaluable help and guidance in doing this work.

I would like to thank our unit Assistant Professors,Dr. B. Sathyamoorthy, M.D., Dr. Parivathini, M.D., Dr. Velmurugan, M.D., Dr. Prabakaran M.D., for their valuable guidance and support throughout the study.

I am greatly indebted to Dr. K. Nedunchezhian, M.D., DCH., for his support and guidance in doing this study.

I sincerely thank all the children and their parents who have submitted themselves for this study and who made it possible.

CONTENTS

INTRODUCTION

Mechanical ventilation (MV) is a life-supporting modality that is used in a significant proportion of patients in intensive care units , the term mechanical ventilation refers to various artificial means used to support ventilation and oxygenation[1, 2]

Mechanical ventilation is commonly delivered in intensive care by positive pressure ventilation. Positive pressure ventilation modes are defined by inspiratory events. Expiration is treated as an independent entity. The primary expiratory parameter, positive end expiratory pressure (PEEP) can be applied to any of the ventilator modes.

VENTILATOR MODES [3, 4]

The various modes of ventilation are classified based on the types of breaths that are selected. The modes most commonly used in pediatric practice are discussed here.

Volume targeted modes :

1. *Controlled Mechanical Ventilation (CMV):* In this mode, the ventilator controls all the ventilation while patient has minimal or no respiratory effort. This is the mode used at the initiation of mechanical ventilation.

2. *Assisted Mechanical Ventilation (AMV):* All breaths are triggered when the patient's inspiratory effort exceeds the preset sensitivity threshold of negative pressure. In all other respects, it is similar to controlled mechanical ventilation.

3. *Assist Control Ventilation (ACV):* ACV is a combination of AMV and CMV. In this mode, the patient initiates the breathing as in AMV. However, if the patients fails to initiate the breathing within a prescribed time the ventilator triggers the breathing and provides a controlled breath as in CMV, thus ensuring a guaranteed minute ventilation.

4. *Intermittent Mandatory Ventilation (IMV):* It is essentially a combination of spontaneous breathing and CMV. A modified circuit provides a continuous gas flow that allows the patient to breathe spontaneously with minimal work of breathing, At a predetermined frequency, the ventilator provides a positive pressure breath to the patient.

5. *Synchronized Intermittent Mandatory Ventilation (SIMV):* SIMV allows the patient to trigger a mandatory breath in the assist mode thereby synchronizing it with the patient's respiratory effort. However, if the patient does not trigger a breath within an allotted time; the ventilator delivers a conventional breath.

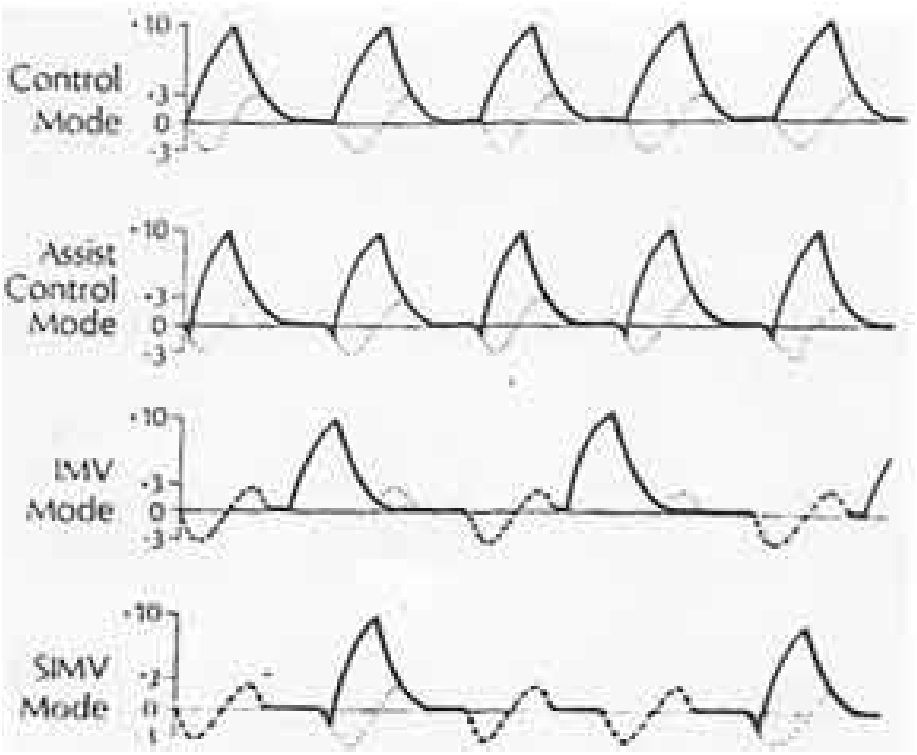


Fig. 1. Airway pressure tracings of the four commonly used volume targeted modes. Thick solid lines represent ventilator breaths; thick dotted lines represent spontaneous breaths; and thin dotted lines represent spontaneous pattern if there are no ventilator breaths.

Pressure targeted modes :

1. *Pressure Support Ventilation (PSV):*In this mode, the patient triggers the breath as in assisted ventilation. Once initiated the ventilator delivers air and gas mixture at a preset positive pressure in the ventilatory circuit. Patients

determine their own inspiratory time and tidal volume. It is mainly used as a weaning mode and may be tolerated better than SIMV by some patients.

2. *Pressure Control and Pressure Assist Control Ventilation (PCV and PACV):*

This is a time-initiated, pressure-limited and time-cycled mode intended for patients requiring total mechanical ventilatory support. Most ventilators also allow patient triggering of these breaths; producing pressure assisted breaths.

Continuous Positive Airway Pressure :

CPAP is best described as PEEP during spontaneous respiration. It is started at 5 cm water and increased by increments of 3 cm water while monitoring blood gases. If PaO2 remains <50 mm Hg despite CPAP of 10-12 cm water with FiO2 of 1 assisted ventilation is warranted.

INDICATIONS [5, 6, 7]

Common indications for mechanical ventilation include the following:

1. Bradypnea or apnea with respiratory arrest
2. Acute lung injury and the acute respiratory distress syndrome
3. Tachypnea (respiratory rate > that for the age)

4. Arterial partial pressure of oxygen (PaO_2) with a supplemental fraction of inspired oxygen (FIO_2) of less than 55 mm Hg

5. Alveolar-arterial gradient of oxygen tension (A-a DO_2) with 100% oxygenation of greater than 450 mm Hg

6. Clinical deterioration

7. Respiratory muscle fatigue

8. Obtundation or coma

9. Hypotension

10. Acute partial pressure of carbon dioxide ($PaCO_2$) greater than 50 mm Hg with an arterial pH less than 7.25

11. Neuromuscular disease

COMPLICATIONS[5, 8]

Common complications of mechanical ventilation are

1. Complications that are associated with intubation:

Nasal trauma, tooth avulsion, oral-pharyngeal laceration, laceration or hematoma of the vocal cords, tracheal laceration, perforation, hypoxemia,

intubation of the esophagus, Sinusitis, tracheal necrosis or stenosis, glottic edema etc.,

2. Ventilator induced complications:

Barotrauma

Volutrauma

Oxygen toxicity

Ventilator-associated pneumonia

Intrinsic PEEP, or auto-PEEP

Cardiovascular effects - decrease preload, stroke volume, and cardiac output.

WEANING FROM VENTILATOR

Once a patient recovers from the illness leading to the application of mechanical ventilation, discontinuation of ventilator support and extubation must be attempted. The discontinuation process consists of two components: weaning (assessing the need for ventilatory support) and extubation (assessing the need for an airway). Investigators have increasingly focused on the latter component, where 5–20% of extubations may fail and require reintubation. In case of unplanned extubation need for reintubation can be as high as 23% to 78%[9].

Both unnecessarily delayed extubation and 'premature' extubation are associated with adverse outcomes. Delayed extubation is associated with increased length of stay, increased risk for ventilator-associated pneumonia, and increased mortality in brain-injured patients. Conversely, reintubation (extubation failure)[10,11] after planned extubation is associated with adverse outcomes, including increased hospital mortality, prolonged hospital stay, higher costs, and greater need for tracheotomy and transfer to post acute care. Although the adverse effects of reintubation could reflect the severity of underlying illness or could result from complications during reintubation, this has not been demonstrated with multivariate analysis. Rather, delayed reinstitution[11] of ventilatory support may allow for deterioration and new organ failure, ultimately contributing to increased mortality and increased costs.

WEANING[12]:

It is the process of withdrawing mechanical ventilatory support and transferring the work of breathing from the ventilator to the patient. It may be done abruptly or gradually.

Patients who were ventilated for relatively short time (usually no more than 1 or 2 days) tolerate an abrupt termination of ventilatory support. But

for most other patients successful weaning requires more gradual withdrawal of ventilatory support.

WEANING PROCEDURES[12]:

Commonly used are T – tube weaning, synchronized intermittent mandatory ventilation (SIMV), continuous positive airway pressure / pressure support (CPAP/PSV) ventilation.

WEANING SUCCESS[12]:

Defined as effective spontaneous breathing without any mechanical assistance for 48 hours or more

WEANING FAILURE[12]:

Weaning failure is defined as one of the following: 1) reintubation and/or resumption of ventilatory support following successful extubation with in 48 hrs or

2) death within 48 h following extubation.

Weaning from mechanical ventilators depends on the strength of respiratory muscles, the load applied to those muscles, and the respiratory drive to breathe. Respiratory failure may occur because of any of these. The etiology of unsuccessful weaning is the imbalance between the respiratory muscle pump and the respiratory muscle load [13,14]. This could happen secondary to inadequate resolution of initial problem that rendered the

patient on mechanical ventilator, a rise of a new problem, a ventilator-associated complication, or a combination of these factors.

The key elements to optimize weaning [15,16] are: *(i)* to determine cause of ventilator dependency,*(ii)* rectify correctible problems like pulmonary gas exchange, fluid balance, mental status, acid-base status, electrolyte disturbance, *(iii)* to consider psychological factors, and *(iv)* to optimize posture and provide ambulation. It is imperative to correct these elements for a successful weaning.

An extubation failure[17] may occur secondary to upper airway obstruction or respiratory secretions that could not be managed by the patient. These factors do not manifest themselves until the removal of the translaryngeal tube. Significant trauma to the airway from translaryngeal intubation is more common in females and increases with increasing duration of intubation[17]. Another potential reason for extubation failure is the loss of positive pressure in the thorax after extubation in pressure support ventilation (PSV)- weaned patients.

A team approach and an organized problem-orientated plan are important to expect successful discontinuation of mechanical ventilation. Ely *et al*[18] recently demonstrated that a protocol of weaning is superior to the physician's individual decision-making at the bedside.

Those investigators found that removal from mechanical ventilation was 2 days earlier in the protocol-directed group[18]. The use of the protocol to manage just four patients (95% confidence interval 3-5) would result in one individual being off mechanical ventilation after 48 h who otherwise would not have been.

Recognising and treating the process that caused the patient to go on the ventilator is the first goal in liberating him from MV. Weaning procedures are usually started only after the underlying disease process that necessitated mechanical ventilation has significantly improved or is resolved. The patient should also have an adequate gas exchange (most studies define this condition as an arterial oxygen tension/fractional inspired oxygen ratio higher than 200), appropriate neurological and muscular status, and stable cardiovascular function.

Weaning indices are objective criteria that are used to predict the readiness of patients to maintain spontaneous ventilation. Some parameters based on respiratory mechanics, gas exchange, and breathing pattern have been proposed as useful predictors of weaning outcome that could guide clinicians in determining the optimal time to discontinue mechanical ventilation [19-22].

Guidelines for weaning

These guidelines, published in 2001[23] , were developed by a collective task force comprising physicians, nurses, and respiratory therapists.

1. Search for all causes for the patient being ventilator-dependent and correct or reverse them.

2. Perform a formal assessment about readiness to wean if the patient meets the criteria listed below. Some patients may still be considered for weaning even if one of the following criteria is not met:

• The cause of the respiratory failure has been partially or fully reversed.

• The patient's Pao2/FIO2 > 200, positive end-expiratory pressure is between 0 and 8 cm H2O, his FIO2 is less than 0.5, and pH is 7.25 or greater.

• The patient's hemodynamic status is stable, with no ischemia and no clinically important hypotension.

• The patient can initiate an inspiratory effort.

3. Perform a formal assessment of readiness to wean. If the patient can tolerate a 30- to 120-minute spontaneous breathing trial, he's ready. Tolerance is based on respiratory pattern (no retractions or obvious signs of

distress and respiratory rate less than 30 breaths/minute), adequate gas exchange, hemodynamic stability, and subjective comfort level.

4. Once the patient is discontinued from mechanical ventilation, assess airwaypatency and his ability to clear secretions. If the airway isn't patent, or if he can't clear secretions, leave the artificial airway in place.

5. If he failed the spontaneous breathing trial, determine and correct the cause. Then evaluate him based on guideline 2. If criteria are met, perform a spontaneous breathing trial every 24 hours.

6. Between breathing trials, use a ventilator mode that provides support that is stable, nonfatiguing, and comfortable. Let the patient rest to avoid overloading the ventilatory muscles.

7. Use proper analgesics and sedatives at the lowest possible dose, to avoid blunting the respiratory drive.

8. Employ properly designed weaning protocols performed by a therapist team.

9. If the patient will clearly need prolonged mechanical ventilation, he should have a tracheostomy. Early in the course of treatment is better than later.

10. A patient should be classified as permanently ventilator-dependent only after 3 months of failed weaning attempts, unless he clearly has irreversible disease or injury, such as amyotrophic lateral sclerosis or spinal cord injury.

11. If weaning attempts in the ICU have failed, transfer a medically stable patient to a specialized facility that has a good safety and success record in accomplishing ventilator discontinuation.

12. When a patient has been on prolonged mechanical ventilation, go slowly in weaning and gradually increase the time used for spontaneous breathing trials. Respiratory muscles need to be retrained and strengthened for patients who've been ventilator-dependent for prolonged periods.

Once a patient has been considered ready to be weaned, the best method to assess whether the patient is able to breathe on his or her own is to perform a trial of spontaneous ventilation. Ely *et al*[18] showed that immediate extubation after successful trials of spontaneous breathing expedites weaning and reduces the duration of mechanical ventilation as compared with a more gradual discontinuation of ventilatory support. Several studies[24-30] have demonstrated that 60-80% of mechanically ventilated patients can be successfully extubated after passing a trial of spontaneous breathing.

Pressure-support, continuous positive airway pressure and T-piece trials are the most common methods used to test the readiness for liberation from mechanical ventilation. Few random studies[26,31] have studied the best technique for performing spontaneous breathing trials before extubation. The first study[31] that dealt with this issue compared continuous positive airway pressure of 5 cmH_2O and T-piece in a group of 106 mechanically ventilated patients who underwent a 1h trial of spontaneous breathing, and no difference in the percentage of patients failing extubation was found. Because the endotracheal tube imposes a resistive load on the respiratory muscles that is inversely related to its cross-sectional diameter, some clinicians advocate use of 5-8 cmH_2O pressure support to offset this imposed load. With this in mind, the study performed by the Spanish Lung Failure Collaborative Group[26] compared weaning outcome after trials of spontaneous breathing with either T-tube or pressure support of 7 cmH_2O, but no difference was observed in the percentage of patients who remained extubated for 48 h (63% in the group assigned to T-tube and 70% in the group assigned to pressure support; $P = 0.14$).

The duration of a spontaneous breathing trial has been set at 2 h in most Studies[26-29]. One prospective, multicenter, randomized trial[30] of 526 patients found that trials of spontaneous breathing for 30 or 120 min were

equivalent in identifying patients who could tolerate extubation, and that patients had reintubation rates of approximately 13% at 48 h regardless of the duration of their T-tube trial.

Precise criteria for terminating a weaning trial do not exist, and currently trials are terminated on the basis of the clinical judgement of the physician. There are two types of criteria used to determine whether a patient passes or fails a spontaneous breathing trial: objective criteria[32,33] (abnormal arterial blood gas measurements) and subjective criteria (diaphoresis, evidence of increasing effort, tachycardia, agitation, anxiety). Patients have clearly failed a spontaneous breathing trial if they develop hypercapnia or hypoxaemia. The evaluation of clinical tolerance to spontaneous breathing by using exclusively subjective criteria has important drawbacks; on the one hand, strict criteria might increase the occurrence of unnecessarily prolonged mechanical ventilation but, on the other hand, permissive criteria might increase the occurrence of reintubation.

Commonly recommended criteria for stopping spontaneous breathing

Inability to maintain gas exchange - SPO2 < 95% with FiO2 of 0.4
Inability to maintain effective ventilation - PCO2 of > 50 mm/Hg or increase of > 10mm/Hg from previous value - pH < 7.3
Increased work of breathing - Respiratory rate in acceptable range < 6 months 20 – 60 / min 6m to 2 yrs 15 – 45 / min 2 to 5 yrs 15 – 40 / min > 5 yrs 10 – 35 / min - increased use of accessory muscles of respiration - paradoxical breathing
Signs of distress - diaphoresis - anxiety - change in mental status(agitation/somnolence) - BP – hyper/ hypo tension - Heart rate – Brady/ tachy cardia

There is little risk in performing a closely observed trial of spontaneous breathing in patients in whom any acute respiratory failure has resolved and who are awake and cardiovascularly stable, in order to assess their ability to sustain spontaneous breathing[34,35]. When the patient remains clinically stable with no signs of poor tolerance until the end of the trial, the endotracheal tube should be immediately removed. If the patient develops

signs of poor tolerance, weaning is considered to have failed and mechanical ventilation is reinstituted[34-38] .

Weaning attempts that are unsuccessful usually indicate incomplete resolution of the illness that precipitated the need for mechanical ventilation, or the development of new problems. Failure to wean has been attributed to an imbalance between the load faced by the respiratory muscles and their neuromuscular competence. If a compensated balance of strength and load cannot be restored, attempts at spontaneous breathing will be futile. Therefore, once a patient fails a spontaneous breathing trial, the clinician must comprehensively evaluate the patient, looking for ways to improve his or her physiologic status.

Factors that can lead to weaning failure due to the imbalance between ventilatory needs and respiratory capacity [39-42]

<u>Factors that increase the load</u>

1. Bronchospasm
2. Pleural effusion
3. Hyperinflation (intrinsic positive end-expiratory pressure)
4. Airway edema, secretions

5. Pneumothorax

6. Alveolar edema

7. Upper airway obstruction

8. Flail chest

9. Infection

10. Obstructive sleep apnea

11. Obesity

12. Atelectasis

13. Endotracheal tube kinking

14. Ascites

15. Interstitial inflammation and/or oedema

16. Secretions encrustation

17. Abdominal distension

18. Ventilatory circuit resistance

Factors that result in decreased neuromuscular competence

1. Drug overdose
2. Electrolyte derangement
3. Critical illness polyneuropathy
4. Brain-stem lesion
5. Malnutrition

6. Neuromuscular blockers
7. Sleep deprivation
8. Myopathy
9. Aminoglycosides
10. Hypothyroidism
11. Hyperinflation
12. Guillain-Barré syndrome
13. Starvation/malnutrition
14. Drugs, corticosteroids
15. Mysthenia gravis
16. Metabolic alkalosis
17. Sepsis
18. Phrenic nerve injury
19. Myotonic dystrophy
20. Spinal cord lesion

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Esteban *et al*[24] did a comparison of four methods of weaning patients from mechanical ventilation. They carried out a prospective, randomized, multicenter study involving 546 patients who had received mechanical ventilation for a mean (+/- SD) of 7.5 +/- 6.1 days and who were considered by their physicians to be ready for weaning. One hundred thirty patients had respiratory distress during a two-hour trial of spontaneous breathing. These patients were randomly assigned to undergo one of four weaning techniques: intermittent mandatory ventilation, in which the ventilator rate was initially set at a mean (+/- SD) of 10.0 +/- 2.2 breaths per minute and then decreased, if possible, at least twice a day, usually by 2 to 4 breaths per minute (29 patients); pressure-support ventilation, in which pressure support was initially set at 18.0 +/- 6.1 cm of water and then reduced, if possible, by 2 to 4 cm of water at least twice a day (37 patients); intermittent trials of spontaneous breathing, conducted two or more times a day if possible (33 patients); or a once-daily trail of spontaneous breathing (31 patients). Standardized protocols were followed for each technique. The median duration of weaning was 5 days for intermittent mandatory ventilation (first

quartile, 3 days; third quartile, 11 days), 4 days for pressure-support ventilation (2 and 12 days, respectively), 3 days for intermittent (multiple) trials of spontaneous breathing (2 and 6 days, respectively), and 3 days for a once-daily trial of spontaneous breathing (1 and 6 days, respectively). After adjustment for other covariates, the rate of successful weaning was higher with a once-daily trial of spontaneous breathing than with intermittent mandatory ventilation (rate ratio, 2.83; 95 percent confidence interval, 1.36 to 5.89; $P < 0.006$) or pressure-support ventilation (rate ratio, 2.05; 95 percent confidence interval, 1.04 to 4.04; $P < 0.04$). There was no significant difference in the rate of success between once-daily trials and multiple trials of spontaneous breathing. A once-daily trial of spontaneous breathing led to extubation about three times more quickly than intermittent mandatory ventilation and about twice as quickly as pressure-support ventilation. Multiple daily trials of spontaneous breathing were equally successful [7].

Brochard *et al* [25]. did a Comparison of three methods of gradual withdrawal from ventilatory support during weaning from mechanical ventilation Among 456 mechanically ventilated patients who met weaning criteria, 109 entered into the study (35 with T piece, 43 with SIMV, and 31

with PSV). The three groups were comparable in terms of etiology of disease or characteristics at entry in the study. When all causes for weaning failure were considered, a lower number of failures was found with PSV than with the other two modes, with the difference just reaching the level of significance (23% for PSV, 43% for T piece, 42% for SIMV; $p = 0.05$). After excluding patients whose weaning was terminated for complications unrelated to the weaning process, the difference became highly significant (8% for PSV versus 33% and 39%, $p < 0.025$) [8]

Esteban *et al* [26]. also compared the extubation outcome after spontaneous breathing trials with T- tube or pressure support ventilation. Patients were randomly assigned to undergo a 2-h trial of spontaneous breathing in one of two ways: with a T-tube system or with pressure support ventilation of 7 cm H2O. If a patient had signs of poor tolerance at any time during the trial, mechanical ventilation was reinstituted. Patients without these features at the end of the trial were extubated. Of the 246 patients assigned to the T-tube group, 192 successfully completed the trial and were extubated; 36 of them required reintubation. Of the 238 patients in the group receiving pressure support ventilation, 205 were extubated and 38 of them

required reintubation. The percentage of patients who remained extubated after 48 h was not different between the two groups (63% T-tube, 70% pressure support ventilation, p= 0.14). The percentage of patients failing the trial was significantly higher when the T-tube was used (22 versus 14%, p = 0.03). Clinical evolution during the trial was not different in patients reintubated and successfully extubated. ICU mortality among reintubated patients was significantly higher than in successfully extubated patients (27 versus 2.6%, p 0.001). Spontaneous breathing trials with pressure support or T-tube are suitable methods for successful discontinuation of ventilator support in patients without problems to resume spontaneous breathing.

Jones *et al*[43]. compared the effects of extubation after 1 h of either CPAP 5 & T – piece . 106 patients were randomized to 1 h CPAP or 1 h T – piece . no significant difference existed between groups in age , sex , HR , BP , FIO2 , PaCO2 , or PaO2. However P(A – a)O2 was significantly higher in CPAP group at the end of 120 min. 19 T – piece patients showed improved P(A – a) O2 at 120 min compared with only 10 patients in CPAP group. 3 CPAP and 2 T – piece patients subsequently required reintubation. This study demonstrates that use of a T – piece does not impair arterial oxygenation and may in fact be superior to extubation from CPAP

STUDY JUSTIFICATION

Once a patient recovers from the illness leading to the application of mechanical ventilation, discontinuation of ventilator support and extubation must be attempted. Failure of extubation is associated with high mortality rate, either by selecting for high-risk patients or by inducing deleterious effects such as aspiration, atelectasis and pneumonia.

There are various standard protocols to classify which child is to be weaned and which not. But once the decision to wean from mechanical ventilator is made there is no universally accepted protocol as to which method of weaning is best. There is uncertainty about the best methods for conducting this process.

Current practice in our PICU as far as weaning is concerned is *physician directed weaning.* Physician directed weaning is an accepted mode of weaning where the intensive care specialist who by his experience decides as which patient is ready for weaning and which method of weaning is to be followed. Since all the methods of weaning are standard methods, patients are randomly weaned using any one method as wished by the physician. There is either undue delay to wean a right patient or an unnecessary early extubation in some patients which increase the duration of ventilation and

need for reintubation respectively in them, both of which are associated with increased rate of mortality & morbidity.To avoid such complications there need to be a single standard effective method which could be applied at any time the patient becomes fit for weaning.

All 3 methods of weaning are accepted universally. But recent researches (most of them conducted in adults) actually show that one method is better over the other. Some studies show t- piece trial[24] to be better some saying CPAP/PS is better, as far as weaning success[25] is considered. Even if all methods are equally effective the actual duration of weaning differ from one method to another. For this purpose a comparative study of the various methods of weaning from mechanical ventilators was undertaken at PICU, ICH & HC where > 500 patients are intubated and ventilated per year to find out a quick and effective method of weaning so that more patients would be benefited from the minimal number of ventilators available. The study was approved by the hospital ethical committee.

AIM OF THE STUDY

To assess the effectiveness of the 3 standard methods of weaning from mechanical ventilators namely T – tube weaning, synchronized intermittent mandatory ventilation (SIMV) , continuous positive airway pressure / pressure support (CPAP/PSV) ventilation in terms of successful weaning, to assess the incidence of weaning failure and duration of weaning with each and also the duration of hospital stay and outcome of these patients so that the best of the weaning procedure can be followed for successful weaning in future.

MATERIALS AND METHODS

MATERIALS AND METHODS

Study Design

Randomized trial.

Study Place

Pediatric intensive care unit

Institute of child health & hospital for children

Period of study

From June 2009 to November 2010.

Study population

Children between 1 month and 12 years of age.

Inclusion criteria

1. All children who were mechanically ventilated for a period of > 48 hours (irrespective of etiology) through an endotracheal tube and who fulfill standard weaning criteria.
2. Those who are reintubated after 48 hours of extubation and continue to receive mechanical ventilation for > 48 hours & fulfill weaning criteria.

Exclusion criteria

- ventilation for less than 48 hours
- Ventilation with tracheostomy tube
- Spontaneously extubated.
- post operative patients.

Manoeuvre

First step in the process was to get informed consent for inclusion in the study from the patient's care givers. After getting informed consent, children who satisfy the criteria for weaning (as per ANNEXURE 1) are allocated computer generated random numbers and were categorized into group A/B/C accordingly.

WEANING SUCCESS [12] : Defined as effective spontaneous breathing without any mechanical assistance for 48 hours or more

WEANING FAILURE [12]: Defined as one of the following:

1) reintubation and/or resumption of ventilatory support following successful extubation with in 48 hrs or

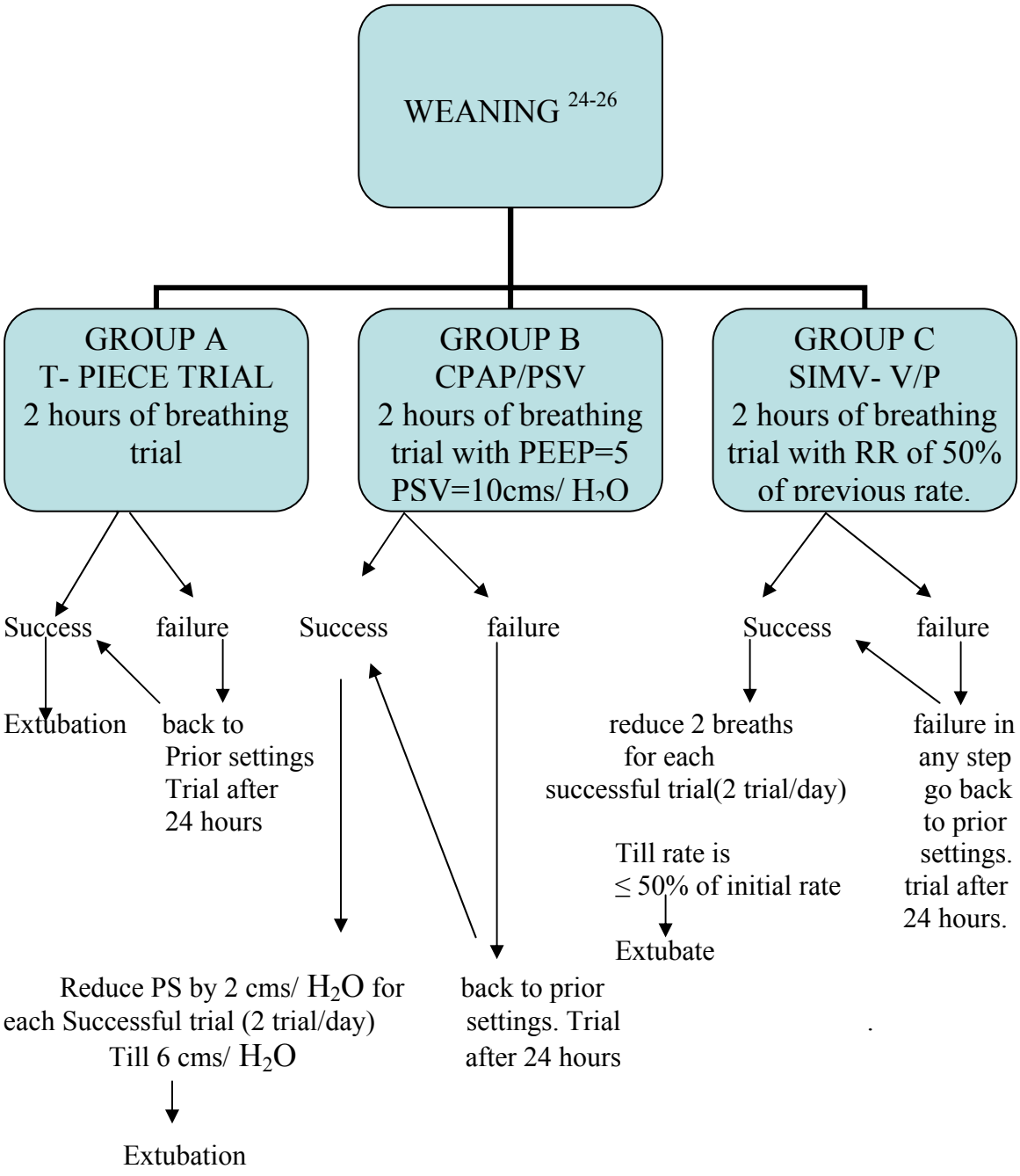
2) death within 48 h following extubation.

TRIAL FAILURE : During a breathing trial if the child developed signs of intolerance.

TRIAL SUCCESS : Successful completion of a 2 hours of breathing trial.

AFTER FULLFILLING WEANING CRITERIA, CHILDREN ARE RANDOMISED

↓



T – piece trial :

After fulfilling weaning criteria the child is connected to a T – piece and a breathing trial for 2 hrs is conducted. If no signs of intolerance child is extubated.

CPAP/PSV :

After fulfilling weaning criteria the child is connected to CPAP/PSV mode with PEEP of 5 & Pressure support of 10. After completion of a 2 hrs of breathing trial PS is reduced by 2 till it comes to 6, then extubation is done. Only 2 successful trials per day one after the other. If there is trial failure next trial is done after 24 hrs.

SIMV :

After fulfilling weaning criteria the child is connected to SIMV mode with a rate that is 50% of the previous rate. After completion of a 2 hrs of breathing trial rate is reduced by 2 till it comes to 50% of the rate at which the trial was started, then extubation is done. Only 2 successful trials per day one after the other. If there is trial failure next trial is done after 24 hrs.

AT ANY POINT DURING TRIAL OF BREATHING IF CHILD FULFILS ANY OF THE CRITERIA (ANNEXURE 2) FOR STOPPING SBT (spontaneous breathing trial) TRIAL IS TERIMINATED ABRUPTLY.

END POINT FOR SIMV TRIAL: till ventilator rate of $\leq$ 50% of initial rate.

END POINT FOR CPAP/PSV TRIAL: till pressure support of 6 cms/ H_2O.

Sample size

Calculated sample size is 30 in each group with a total of 90. 9 additional samples for loss during study period. Total sample size is 99 of which 96 was achieved and 88 completed the study.

Statistical analysis

Chi – square test was used to compare categorical responses between children weaned using T – piece, CPAP – PSV and SIMV methods. One way ANOVA test and Post hoc test were used to compare the mean difference between the three groups.

PROFORMA

NAME			
AGE/SEX			
IP.NO			
RANDOM NUMBER			
GROUP			
DIAGNOSIS			
COMORBIDITY			
Hb%			
DATE/TIME OF INTUBATION			
INDICATION FOR INTUBATION			
TUBE SIZE			
REINTUBATIONS	YES	Number	Indication
		1. 2. 3.	
	NO		

RAPID SEQUENCE INTUBATION	YES		NUMBER				
	NO						
SHOCK	YES		DURATION				
	NO						
INOTROPES	YES		DURATION				
	NO						
MANUAL VENTILATION	YES	STARTED ON: @ ENDED ON: @					
	NO						
MODE OF MECHANICAL VENTILATION PRIOR TO WEANING	ASSISTED VOLUME CONTROL			ASSISTED PRESSURE CONTROL			
	FiO2	Tidal volume	Rate/ min	FiO2	PIP	PEEP	Rate/ min
DURATION OF MECHANICAL VENTILATION PRIOR TO WEANING	STARTED ON: @ ENDED ON: @						
NOSOCOMIAL PNEUMONIA	YES						
	NO						

<table>
<tr><td>WEANING PROCEDURE</td><td colspan="3"></td></tr>
<tr><td>NO OF SBT</td><td colspan="3"></td></tr>
<tr><td>DURATION OF WEANING</td><td colspan="3"></td></tr>
<tr><td rowspan="3">WEANING FAILURE (< 48 hours)</td><td rowspan="2">YES</td><td>REINTUBATION</td><td></td></tr>
<tr><td>DEATH</td><td></td></tr>
<tr><td>NO</td><td colspan="2"></td></tr>
<tr><td rowspan="2">INDICATION FOR REINTUBATION</td><td colspan="3">Airway cause:</td></tr>
<tr><td colspan="3">Non airway cause:</td></tr>
<tr><td>DURATION OF PICU STAY</td><td colspan="3"></td></tr>
<tr><td>DURATION OF HOSPITAL STAY</td><td colspan="3"></td></tr>
<tr><td>OUTCOME</td><td colspan="3">1.death
2.complete recovery from underlying acute illness with out complications
3. complete recovery from underlying acute illness following complications
Complication-

4.sequele:</td></tr>
</table>

RESULTS

RESULTS

Out of the 96 children included in the study 88 children successfully completed the study. 8 children were excluded from the weaning trial due to spontaneous extubation during the course of the trial. All 31 children from group A completed the trial successfully. 31 out of 33 children from group B completed the trial. 26 out of 32 children from group C successfully completed the trial.

TABLE 1

AGE DISTRIBUTION OF CHILDREN IN EACH GROUP

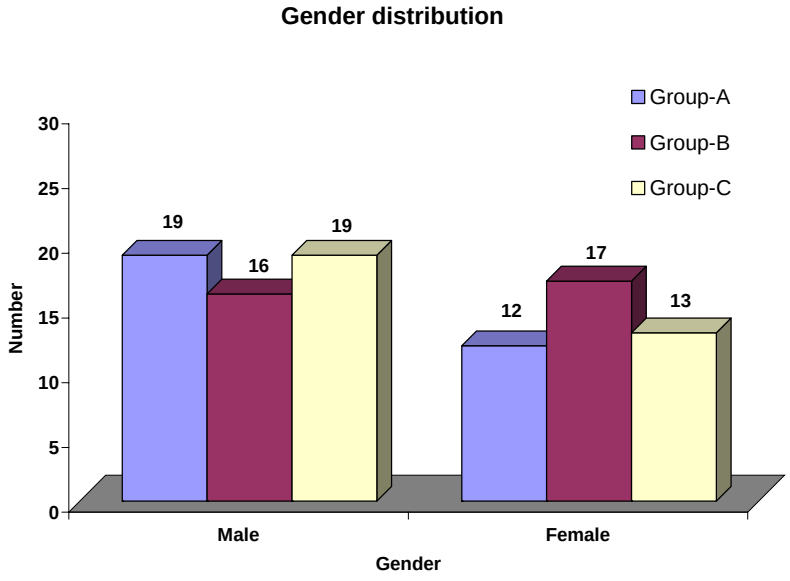
Treatment Group		Frequency	Percent
Group-A	< 1 yr	*20*	*64.5*
	1 – 4 yrs	*10*	*32.3*
	4 – 8 yrs		
	8 – 12 yrs	*1*	*3.2*
	Total	*31*	*100.0*
Group-B	< 1 yr	*20*	*64.5*
	1 – 4 yrs	*7*	*22.6*
	4 – 8 yrs	*3*	*9.7*
	8 – 12 yrs	*1*	*3.2*
	Total	*31*	*100.0*
Group-C	< 1 yr	*11*	*42.4*
	1 – 4 yrs	*8*	*30.8*
	4 – 8 yrs	*6*	*23*
	8 – 12 yrs	*1*	*3.8*
	Total	*26*	*100.0*

SEX DISTRIBUTION OF CHILDREN IN EACH GROUP

61.3 % of children in group A , 45.1 % in group B and 61.5 % in group C were boys and the rest were girls in each group. Both sexes were equally distributed.

TABLE 2

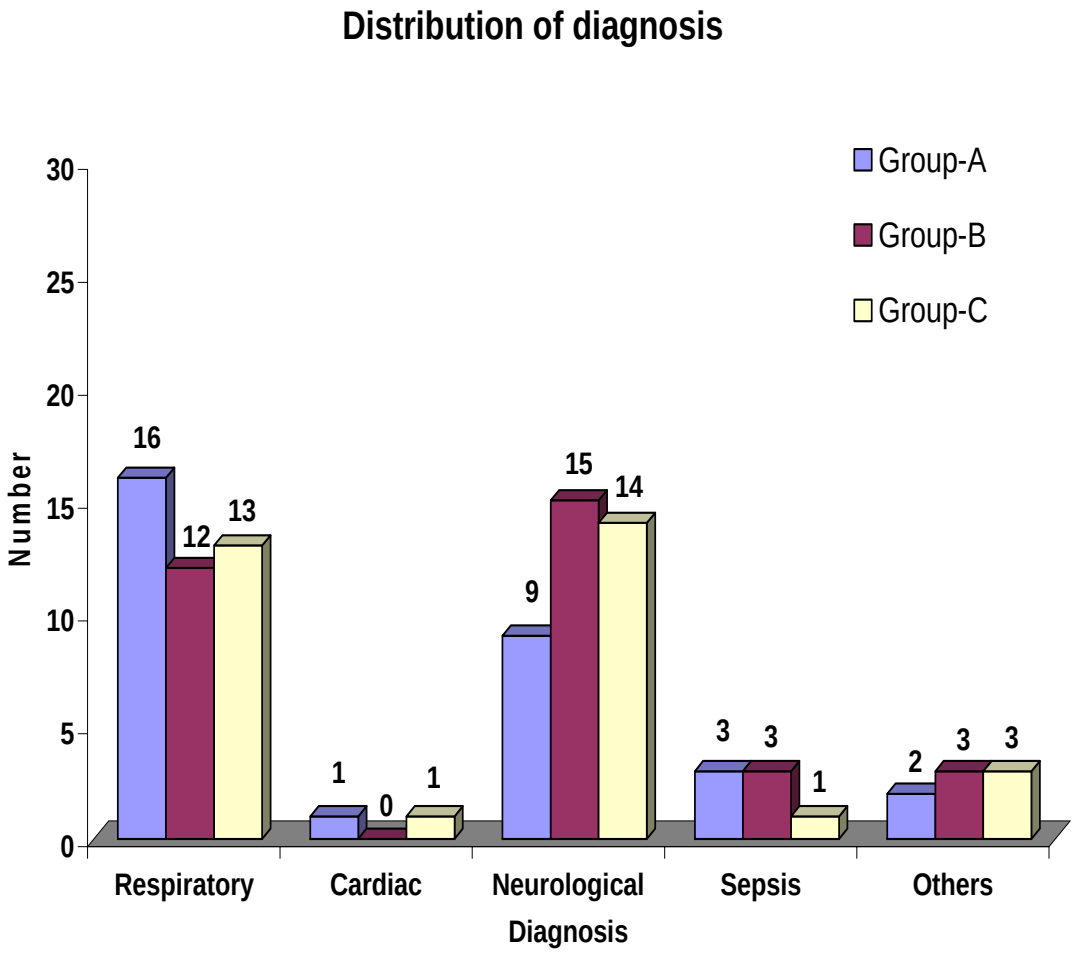
Treatment Group		Frequency	Percent	P value
Group-A	Male	*19*	*61.3*	
	Female	*12*	*38.7*	
	Total	*31*	*100.0*	
Group-B	Male	*14*	*45.1*	
	Female	*17*	*54.9*	
	Total	*31*	*100.0*	*0.342*
Group-C	Male	*16*	*61.5*	
	Female	*10*	*38.5*	
	Total	*26*	*100.0*	



RSI

16.1 % of children in group A , 6.1 % of children in group B and 15.6 % of children in group C were intubated using Rapid Sequence Intubation.

COMPARISONS OF VARIOUS DIAGNOSIS AMONG GROUPS



Respiratory **P - Value: 0.304**
Cardiac **P – Value: 0.566**
Neurological **P – Value: 0.283**
Sepsis **P – Value: 0.913**

TABLE 3

Treatment Group		Frequency	Percent
Group-A	Respiratory	*16*	*51.6*
	Cardiac	*1*	*3.2*
	Neurological	*9*	*29.0*
	Sepsis	*3*	*9.7*
	Others	*2*	*6.5*
	Total	*31*	*100.0*
Group-B	Respiratory	*10*	*32.2*
	Cardiac		
	Neurological	*15*	*48.4*
	Sepsis	*3*	*9.7*
	Others	*3*	*9.7*
	Total	*31*	*100.0*
Group-C	Respiratory	*11*	*42.3*
	Cardiac	*1*	*3.8*
	Neurological	*11*	*42.3*
	Sepsis	*1*	*3.8*
	Others	*2*	*7.8*
	Total	*26*	*100.0*

Neurological illnesses were the major cause of hospitalization among children of 2 groups. 48.4 % in group B , 42.3 % in group C had neurological diseases. But in group A 51.6 % had respiratory diseases. The distribution of diseases was equal among all the 3 groups.

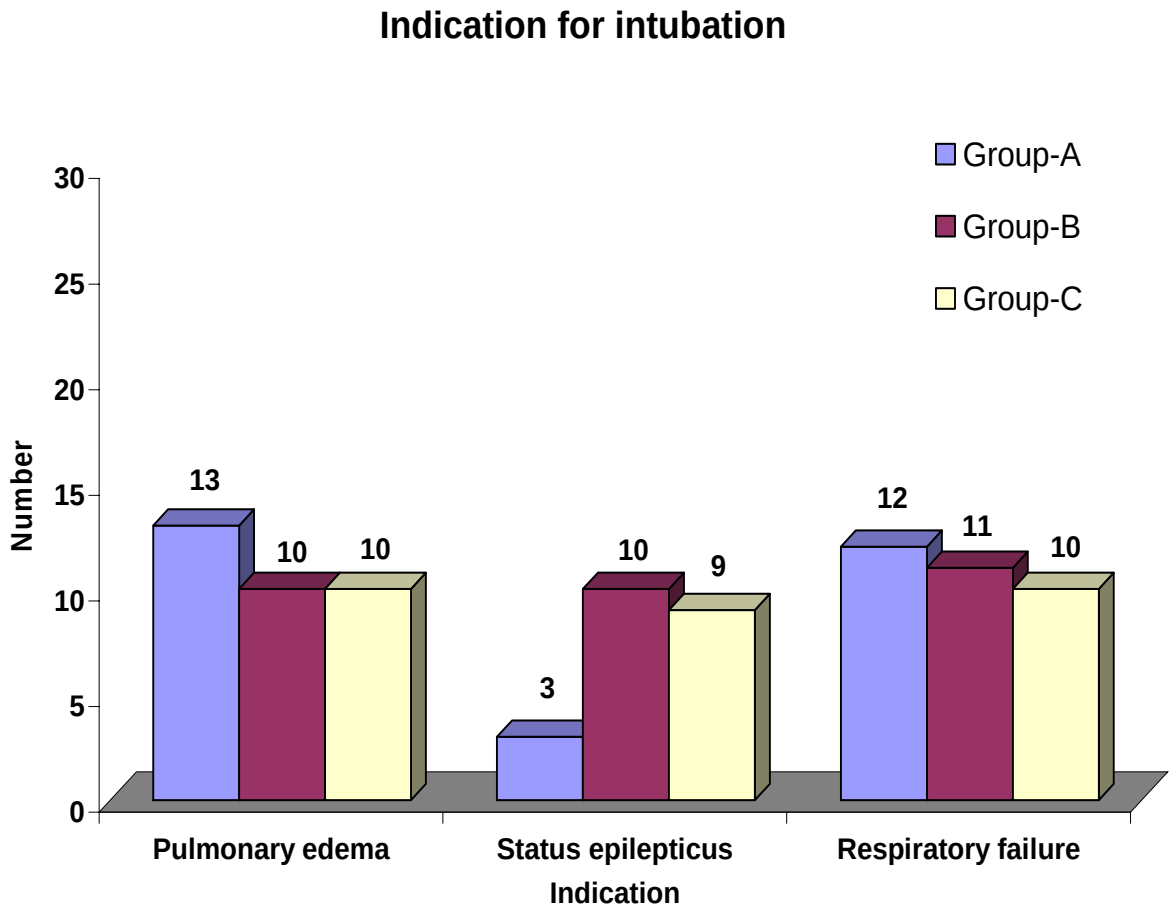
71 % of children in group A , 72.7 % in group B and 62.5 % in group C had no associated co-morbidities.

INDICATION FOR INTUBATION

TABLE 4

Treatment Group		Frequency	Percent
Group-A	Pulmonary edema	*13*	*41.9*
	Status epilepticus	*3*	*9.7*
	Respiratory failure	*12*	*38.7*
	Poor GCS	*3*	*9.7*
	Total	*31*	*100.0*
Group-B	Pulmonary edema	*9*	*29*
	Status epilepticus	*10*	*32.3*
	Respiratory failure	*10*	*32.3*
	Poor GCS	*2*	*6.4*
	Total	*31*	*100.0*
Group-C	Pulmonary edema	*8*	*30.8*
	Status epilepticus	*7*	*27*
	Respiratory failure	*8*	*30.8*
	Poor GCS	*3*	*11.4*
	Total	*26*	*100.0*

Pulmonary edema and respiratory failure were the major indications for intubation among children of all groups. In group A 41.9 % and 38.7 % , in group B 29 % and 32.3 % , in group C 30.8 % had pulmonary edema and respiratory failure respectively. 9.7 % , 32.3 % and 27 % in groups A,B and C were intubated for status epilepticus. Poor GCS was the other indication for intubation in these children.



Pulmonary edema **P – Value:0.514**
Status epilepticus **P – Value:0.088**
Respiratory failure **P – Value:0.791**
Poor GCS **P – Value:0.793**

There was no statistically significant difference in the distribution of the various indications for intubation among groups.

TABLE 5 - SHOCK

Treatment Group		Frequency	Percent	P value
Group-A	No	*9*	*29.0*	
	Yes	*22*	*71.0*	
	Total	*31*	*100.0*	
Group-B	No	*12*	*38.7*	
	Yes	*19*	*61.3*	
	Total	*31*	*100.0*	*0.669*
Group-C	No	*10*	*38.5*	
	Yes	*16*	*61.5*	
	Total	*26*	*100.0*	

TABLE 6 - DURATION OF SHOCK

Treatment Group		Frequency	Percent
Group-A	< 24hrs	*13*	*59.1*
	24 - 48hrs	*6*	*27.3*
	> 48hrs	*3*	*13.6*
	Total	*22*	*100.0*
Group-B	< 24hrs	*9*	*47.4*
	24 - 48hrs	*7*	*36.8*
	> 48hrs	*3*	*15.8*
	Total	*19*	*100.0*
Group-C	< 24hrs	*8*	*50*
	24 - 48hrs	*6*	*37.5*
	> 48hrs	*2*	*12.5*
	Total	*16*	*100.0*

71 % in group A , 61.3 % in group B and 61.5 % in group C had shock during sometimes of their illness. In majority of them shock persisted for < 24 hrs. only 13.6 % , 15.8 % & 12.5 % in group A , B & C had shock for > 48 hrs.

INOTROPES – TABLE 7

Treatment Group		Frequency	Percent
Group-A	No	*12*	*38.7*
	Yes	*19*	*61.3*
	Total	*31*	*100.0*
Group-B	No	*16*	*51.6*
	Yes	*15*	*48.4*
	Total	*31*	*100.0*
Group-C	No	*12*	*46.1*
	Yes	*14*	*53.9*
	Total	*32*	*100.0*

DURATION OF INOTROPES – TABLE 8

Treatment Group		Frequency	Valid Percent
Group-A	< 24hrs	*10*	*52.6*
	24 - 48hrs	*6*	*31.6*
	> 48hrs	*3*	*15.8*
	Total	*19*	*100.0*
Group-B	< 24hrs	*5*	*33.3*
	24 - 48hrs	*7*	*46.7*
	> 48hrs	*3*	*20*
	Total	*15*	*100.0*
Group-C	< 24hrs	*6*	*42.8*
	24 - 48hrs	*6*	*42.8*
	> 48hrs	*2*	*14.4*
	Total	*14*	*100.0*

More than 50 % of children received inotropic support for shock management. Only in group B (46.7 %) inotropes were used for 24 – 48 hrs where as in groups group A (52.6 %) and group C (42.8 %) inotropes were used only for < 24 hrs.

VENTILATION BEFORE WEANING

26 out of 31 children (84 %) in group A , 29 out of 31 children (93.5 %) in group B and 24 of 26 children (92.3 %) in group C received manual ventilation prior to mechanical ventilation which was equally distributed among groups.

29 out of 31 (93.5 %) in group A , 28 out of 31 (90.3 %) in group B and 21out of 26 (80.8 %) in group C received pressure control ventilation before weaning.

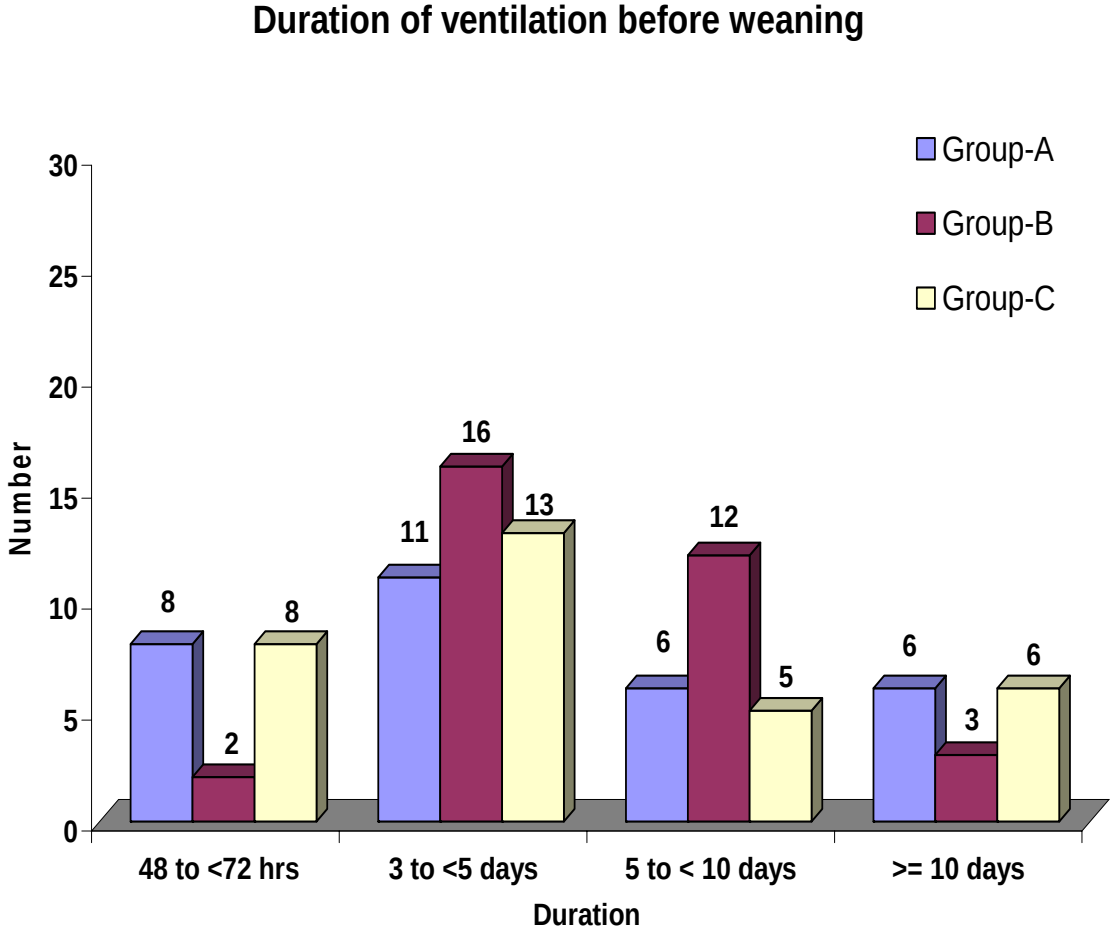


TABLE 9

DURATION OF VENTILATION PRIOR TO WEANING

Treatment Group		Frequency	Percent	P value
Group-A	48 to <72 hrs	*8*	*25.8*	*0.226*
	3 to <5 days	*11*	*35.5*	
	5 to < 10 days	*6*	*19.4*	
	>= 10 days	*6*	*19.4*	
	Total	*31*	*100.0*	
Group-B	48 to <72 hrs	*2*	*6.5*	
	3 to <5 days	*15*	*48.4*	
	5 to < 10 days	*11*	*35.5*	
	>= 10 days	*3*	*9.6*	
	Total	*31*	*100.0*	
Group-C	48 to <72 hrs	*6*	*23.1*	
	3 to <5 days	*10*	*38.5*	
	5 to < 10 days	*5*	*19.2*	
	>= 10 days	*5*	*19.2*	
	Total	*26*	*100.0*	

The duration of ventilation prior to weaning was equally distributed among groups. There is no significant difference since the **P value is 0.226**

WEANING CRITERIA

TABLE 10 - NUMBER OF CRITERIA FULFILLED

Treatment Group		Frequency	Percent
Group-A	7		
	8	*18*	*58.1*
	9	*13*	*41.9*
	Total	*31*	*100.0*
Group-B	7	*1*	*3.2*
	8	*12*	*38.7*
	9	*18*	*58.1*
	Total	*31*	*100.0*
Group-C	7	*2*	*7.7*
	8	*9*	*34.6*
	9	*15*	*57.7*
	Total	*26*	*100.0*

All 9 criteria were fulfilled by 41.9 % , 61.5 % & 57.7 % of children in groups A , B & C respectively.

8 criteria were fulfilled by 58.1 % , 35.5 % & 34.6 % of children in groups A , B & C respectively.

7 criteria were fulfilled by 3.2 % & 7.7 % of children in groups B & C respectively.

NOSOCOMIAL PNEUMONIA

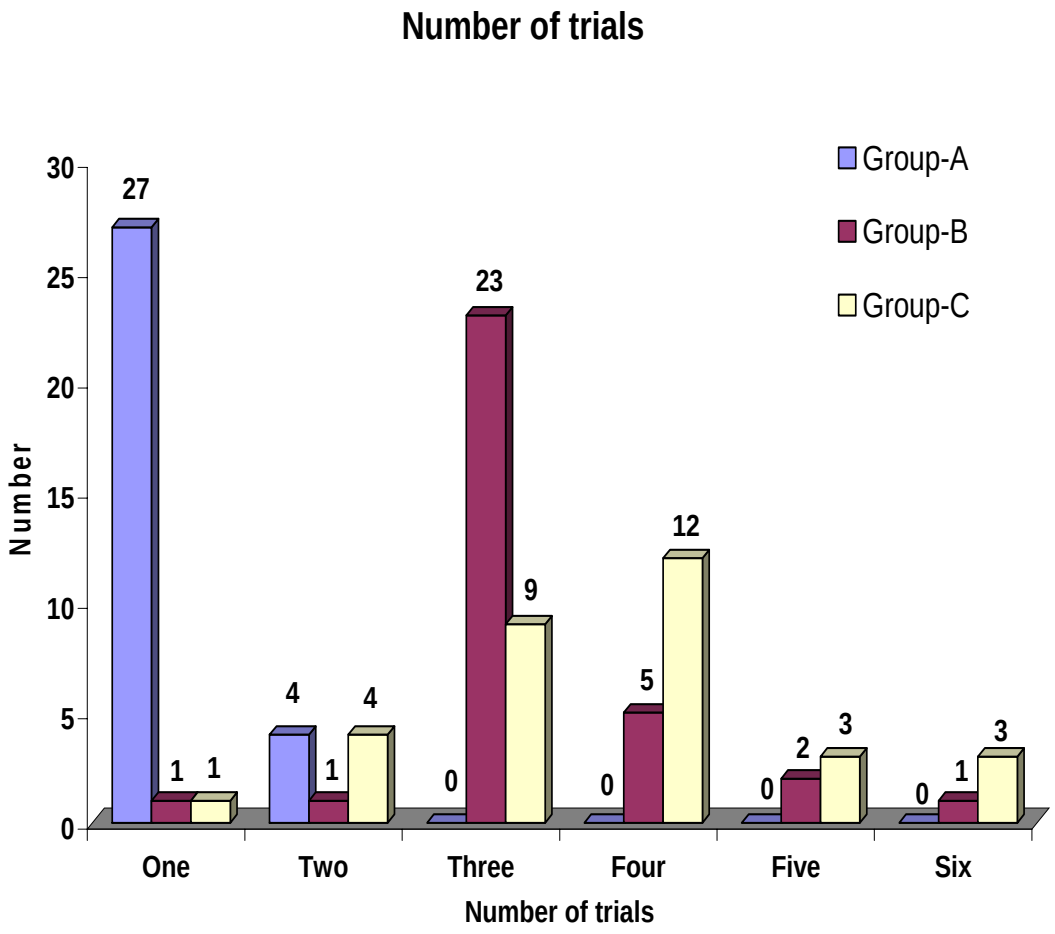
TABLE 11

Treatment Group		Frequency	Percent	P value
Group-A	Yes	*1*	*3.2*	***0.023***
	No	*30*	*96.8*	
	Total	*31*	*100.0*	
Group-B	Yes	*9*	*29*	
	No	*22*	*71*	
	Total	*31*	*100.0*	
Group-C	Yes	*6*	*23*	
	No	*20*	*77*	
	Total	*26*	*100.0*	

The incidence of nosocomial pneumonia was significantly lower in group A (1 out of 31 = 3.2 %) than in group B (9 out of 31 = 29 %) and group C (6 out of 32 = 23 %). This was **statistically significant with a P value of 0.023.**

WEANING TRIALS

NUMBER OF TRIALS



27 out of 31 children in group A (87.1 %) required only 1 trial for weaning. Whereas in group B 23 out of 31 (74.1 %) children required 3 trials. In group C 12 out of 26 (46.1 %) children needed 4 trials and 8 out of 26 (30.7 %) needed 3 trials thereby increasing the duration of weaning in groups B & C.

TABLE 12

Oneway ANOVA test for number of trials

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval		Range		P value
					Lower Bound	Upper Bound	Minimum	Maximum	
Group-A	*31*	*1.13*	*.341*	*.061*	*1.00*	*1.25*	*1*	*2*	***0.000***
Group-B	*31*	*3.27*	*.876*	*.152*	*2.96*	*3.58*	*3*	*6*	
Group-C	*26*	*3.66*	*1.208*	*.214*	*3.22*	*4.09*	*3*	*6*	
Total	*88*	*2.71*	*1.414*	*.144*	*2.42*	*2.99*	*1*	*6*	

Number of trials needed for weaning was least in group A with a mean of 1.13 where as in groups B & C it was 3.27 & 3.66 respectively. This was **statistically significant with a P value of 0.000.**

TABLE 13

post Hoc test - Multiple Comparisons

(I) Treatment Group	(J) Treatment Group	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Group-A	Group-A					
	Group-B	*-2.14(*)*	*.222*	***.000***	*-2.68*	*-1.60*
	Group-C	*-2.53(*)*	*.224*	***.000***	*-3.07*	*-1.98*
Group-B	Group-A	*2.14(*)*	*.222*	***.000***	*1.60*	*2.68*
	Group-B					
	Group-C	*-.38*	*.220*	*.255*	*-.92*	*.15*
Group-C	Group-A	*2.53(*)*	*.224*	***.000***	*1.98*	*3.07*
	Group-B	*.38*	*.220*	*.255*	*-.15*	*.92*
	Group-C					

* The mean difference is significant at the .05 level.

Even on multiple comparisons group A was found to have statistically significant less number of trials (**P value of 0.000**) than group B & C. There was no statistically significant difference between groups B & C.

NUMBER OF TRIAL FAILURE

TABLE 14

Treatment Group		Frequency	Percent
Group-A	0	*27*	*87.1*
	1	*4*	*12.9*
	2		
	3		
	Total	*31*	*100.0*
Group-B	0	*23*	*74.2*
	1	*6*	*19.3*
	2	*1*	*3.2*
	3	*1*	*3.2*
	Total	*31*	*100.0*
Group-C	0	*14*	*53.8*
	1	*7*	*26.9*
	2	*4*	*15.3*
	3	*1*	*3.8*
	Total	*26*	*100.0*

In group A only 4 out of 31 (12.9%) had 1 trial of SBT failed. In group B 6 out of 31 (19.3%) had 1 trial failure. 3.2% had 2 and 3trial failures respectively. In group C 7 out of 26 (26.9%) , 4 out of 26 (15.3%) and 1 out of 26 (3.8%) had 1, 2 and 3 trial failures respectively.

TABLE 15

Cross table & chi – square test

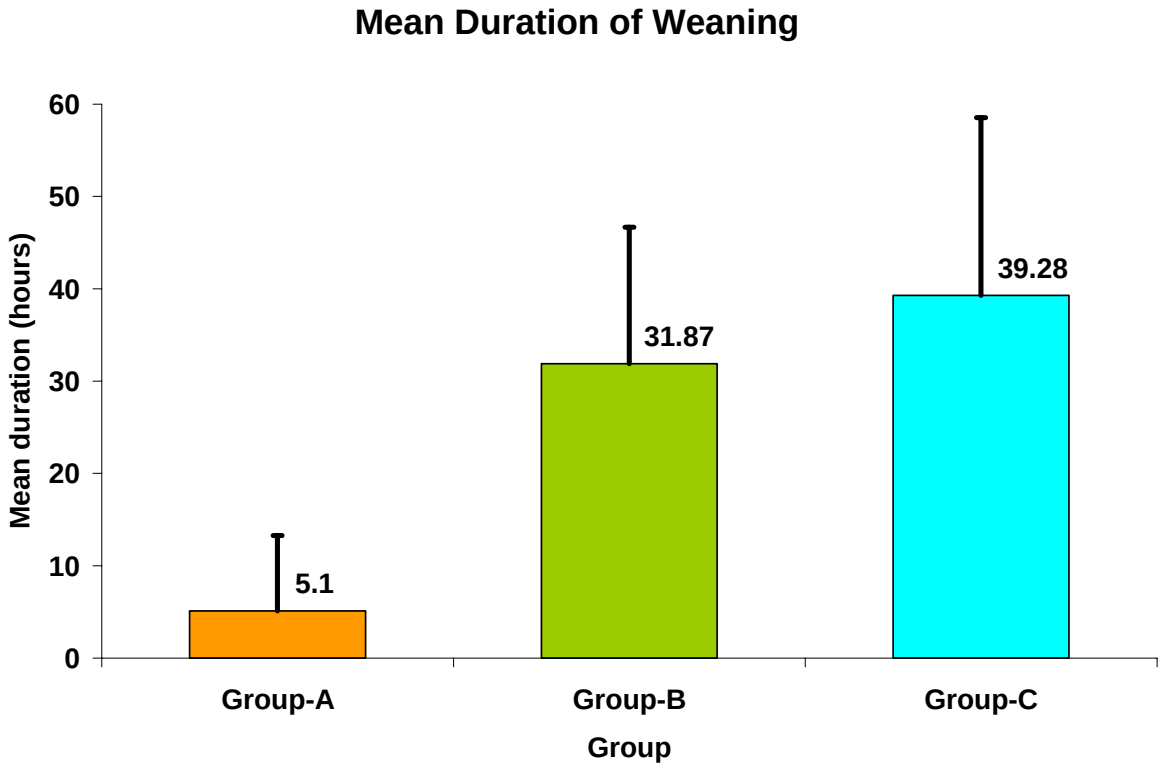
		Treatment Group			Total
		Group-A	**Group-B**	**Group-C**	
No. of trial failure	None	*27*	*23*	*14*	*44*
	Percent	*87.1%*	*74.1%*	*53.8%*	*72.7%*
	One or more	*4*	*8*	*12*	*24*
	Percent	*12.9%*	*25.9%*	*46.2%*	*27.3%*
Total		*31*	*31*	*26*	*88*
		100.0%	*100.0%*	*100.0%*	*100.0%*
P value		***0.041***			

In group A number of trial failures were **significantly less with P value of 0.041** compared with groups B & C.

DURATION OF WEANING

TABLE 16 - One way ANOVA for duration of weaning

	N	Mean (hrs)	Std. Deviation	Std. Error	95% Confidence Interval		Range		P value
					Lower limit	Upper limit	Minimum	Maximum	
Group -A	*31*	*5.10*	*8.179*	*1.469*	*2.10*	*8.10*	*2*	*26*	
Group -B	*31*	*31.87*	*14.796*	*2.657*	*26.44*	*37.30*	*26*	*98*	
Group -C	*26*	*39.28*	*19.250*	*3.850*	*31.33*	*47.23*	*26*	*98*	
Total	*88*	*24.46*	*20.540*	*2.202*	*20.08*	*28.84*	*2*	*98*	***0.000***



The mean duration of weaning in group A is 5.1 hrs, with minimum of 2 hrs and maximum of 26 hrs. In group B it is 31.87 hrs, with minimum of 26 hrs and maximum of 98 hrs. In group C mean duration of weaning is 39.28 hrs, with minimum of 26 hrs and maximum of 98 hrs.

The duration of weaning is shortest in group A (5.1 hrs ± 2.9) which is statistically significant with P value of 0.000.

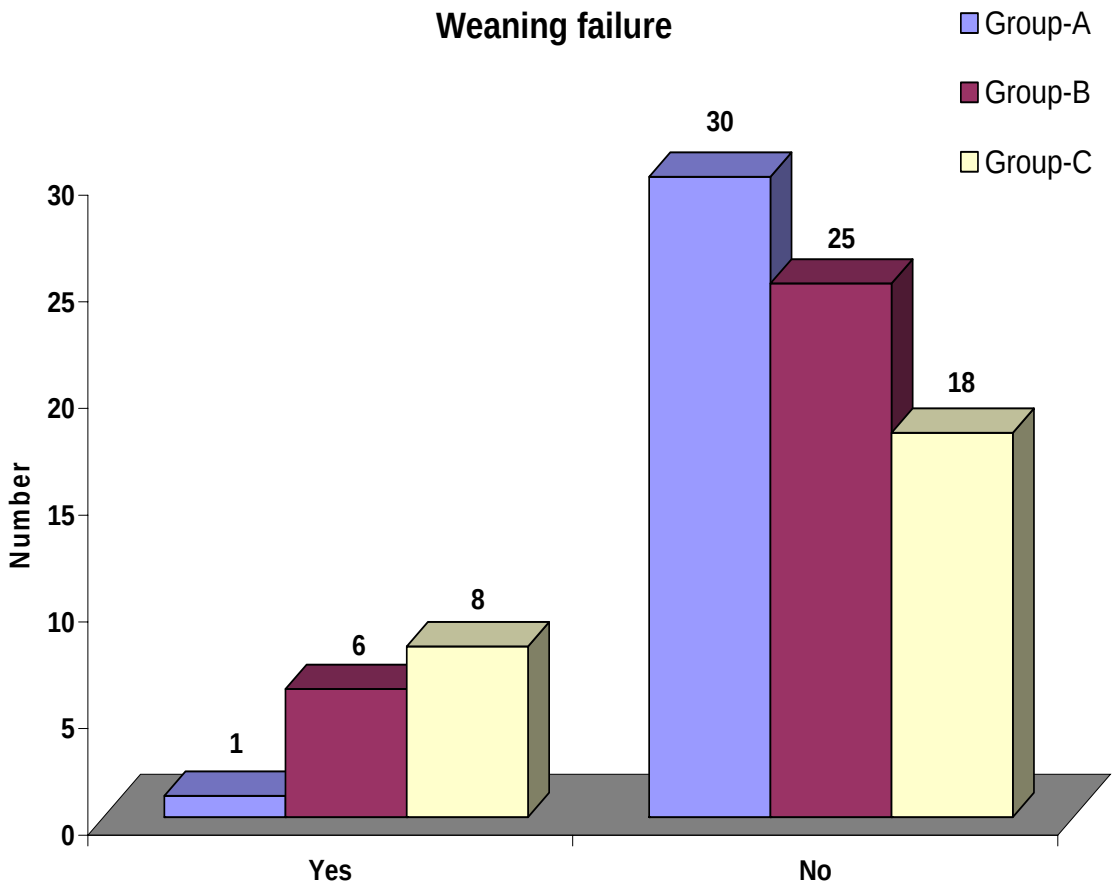
TABLE 17 - Post Hoc Tests - Multiple Comparisons

(I) Treatment Group	(J) Treatment Group	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Group-A	Group-A					
	Group-B	*-26.77(*)*	*3.663*	***.000***	*-35.72*	*-17.83*
	Group-C	*-34.18(*)*	*3.876*	***.000***	*-43.65*	*-24.71*
Group-B	Group-A	*26.77(*)*	*3.663*	***.000***	*17.83*	*35.72*
	Group-B					
	Group-C	*-7.41*	*3.876*	*.178*	*-16.88*	*2.06*
Group-C	Group-A	*34.18(*)*	*3.876*	***.000***	*24.71*	*43.65*
	Group-B	*7.41*	*3.876*	*.178*	*-2.06*	*16.88*
	Group-C					

* The mean difference is significant at the .05 level.

Even on multiple comparisons with groups B and C, **group A was found to have statistically significant shorter duration of weaning with a P value of 0.000.** There was no statistically significant difference among groups B & C.

WEANING FAILURE



In group A 1 out of 31 failed weaning (3.2%)

In group B 6 out of 31 failed weaning (19.4%)

In group C 8 out of 26 failed weaning (30.8%)

Weaning was successful in 96.8% of children in group A , 80.6% of children in group B & 69.2 % of children in group C.

TABLE 18

Weaning failure

Treatment Group		Frequency	Valid Percent	P value
Group-A	No	*30*	*96.8*	
	Yes	*1*	*3.2*	***0.021***
	Total	*31*	*100.0*	
Group-B	No	*25*	*80.6*	
	Yes	*6*	*19.4*	
	Total	*31*	*100.0*	
Group-C	No	*18*	*69.2*	
	Yes	*8*	*30.8*	
	Total	*26*	*100.0*	

Group A had statistically less weaning failure than the other 2 groups with a P value of 0.021.

OUTCOME MEASURES

TABLE 19

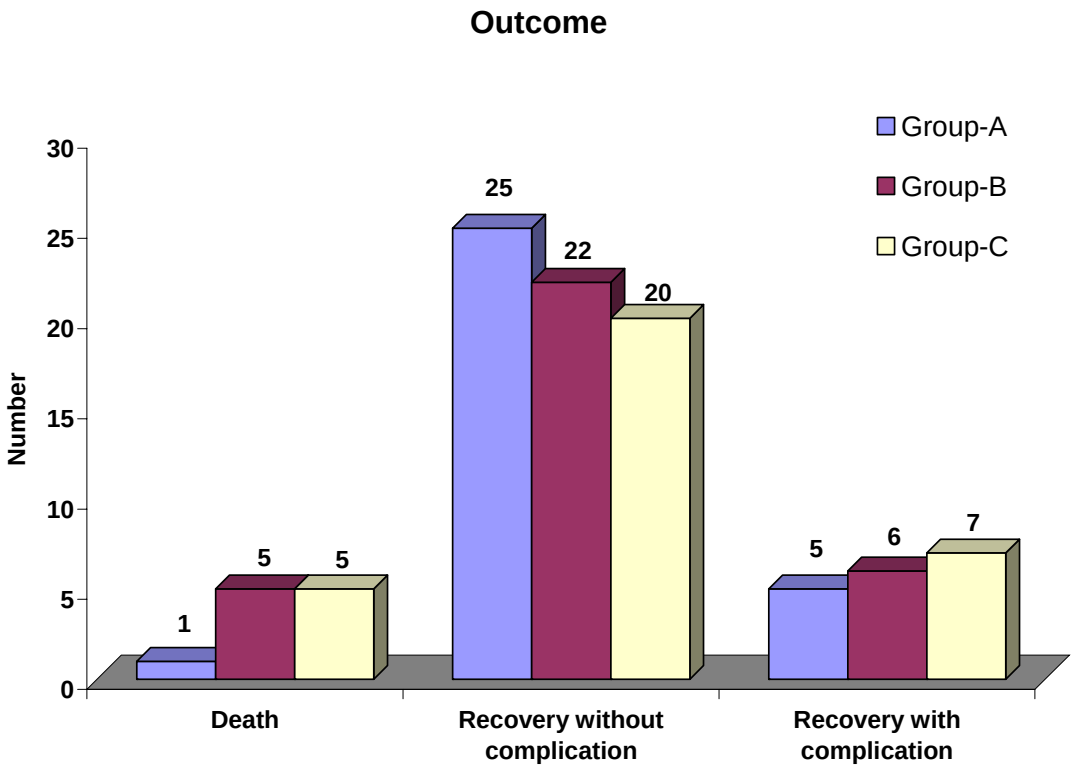
Treatment Group		Frequency	Percent
Group-A	Death	*1*	*3.2*
	Recovery without complication	*25*	*80.6*
	Recovery with complication	*5*	*16.1*
	Total	*31*	*100.0*
Group-B	Death	*5*	*16.1*
	Recovery without complication	*20*	*64.6*
	Recovery with complication	*6*	*19.3*
	Total	*31*	*100.0*
Group-C	Death	*5*	*19.3*
	Recovery without complication	*16*	*61.5*
	Recovery with complication	*5*	*19.2*
	Total	*26*	*100.0*

All children included in the study were followed up throughout their hospital stay and their outcomes were observed.

In group A 80.6 % recovered without complications, 16.1 % recovered with complications & 3.2 % died.

In group B 66.7 % recovered without complications, 18.2 % recovered with complications & 15.2 % died.

In group A 62.5 % recovered without complications, 21.9 % recovered with complications & 15.6 % died.



The outcome measures were not statistically significant between the groups. P value is 0.430.

TABLE 20 - Factors associated with Weaning failure: Group-A

Treatment Group		Weaning failure				Total		*Chi-square value*	*P-Value*
		No		Yes					
		N	%	N	%	N	%		
Number of criteria fulfilled	8	*17*	*94.44*	*1*	*5.56*	*18*	*100*	*0.746*	*0.388*
	9	*13*	*100*			*13*	*100*		
	7								
Sex	Male	*18*	*94.74*	*1*	*5.26*	*19*	*100*	*0.653*	*0.419*
	Female	*12*	*100*			*12*	*100*		
Diagnosis	Respiratory	*16*	*100*			*16*	*100*	*2.526*	*0.640*
	Cardiac	*1*	*100*			*1*	*100*		
	Neurological	*8*	*88.89*	*1*	*11.11*	*9*	*100*		
	Sepsis	*3*	*100*			*3*	*100*		
	Others	*2*	*100*			*2*	*100*		
Comorbidity	No	*21*	*95.45*	*1*	*4.55*	*22*	*100*	*0.423*	*0.516*
	Yes	*9*	*100*			*9*	*100*		
Shock	No	*8*	*88.89*	*1*	*11.11*	*9*	*100*	*2.526*	*0.112*
	Yes	*22*	*100*			*22*	*100*		
Inotropes	No	*11*	*91.67*	*1*	*8.33*	*12*	*100*	*1.636*	*0.201*
	Yes	*19*	*100*			*19*	*100*		
Nosocomial pneumonia	Yes	*1*	*100*			*1*	*100*	*0.034*	*0.853*
	No	*29*	*96.67*	*1*	*3.33*	*30*	*100*		
Number of trial	1	*26*	*96.30*	*1*	*3.70*	*27*	*100*	*0.153*	*0.696*
	2	*4*	*100*			*4*	*100*		
Number of trial failure	0	*26*	*96.30*	*1*	*3.70*	*27*	*100*	*0.153*	*0.696*
	1	*4*	*100*			*4*	*100*		
Total		*30*	*96.77*	*1*	*3.23*	*31*	*100*		

TABLE 21 - Factors associated with Weaning failure: Group-B

Treatment Group		Weaning failure				Total		Chi-square value	P-Value
		No		Yes					
		N	%	N	%	N	%		
Number of criteria fulfilled	8	7	63.64	4	36.36	11	100	3.228	0.199
	9	17	89.47	2	10.53	19	100		
	7	1	100			1	100		
Sex	Male	13	92.86	1	7.14	14	100	2.439	0.118
	Female	12	70.59	5	29.41	17	100		
Diagnosis	Respiratory	7	70.00	3	30.00	10	100	2.170	0.538
	Cardiac								
	Neurological	13	86.67	2	13.33	15	100		
	Sepsis	3	100			3	100		
	Others	2	66.67	1	33.33	3	100		
Comorbidity	No	19	86.36	3	13.64	22	100	1.588	0.208
	Yes	6	66.67	3	33.33	9	100		
Shock	No	9	75.00	3	25.00	12	100	0.400	0.527
	Yes	16	84.21	3	15.79	19	100		
Inotropes	No	13	81.25	3	18.75	16	100	0.008	0.930
	Yes	12	80.00	3	20.00	15	100		
Nosocomial pneumonia	Yes	8	88.89	1	11.11	9	100	0.552	0.457
	No	17	77.27	5	22.73	22	100		
Number of trial	3	21	91.30	2	8.70	23	100	11.613	0.009
	4	3	60.00	2	40.00	5	100		
	5			2	100	2	100		
	6	1	100			1	100		
Number of trial failure	0	21	91.30	2	8.70	23	100	9.691	0.021
	1	3	50.00	3	50.00	6	100		
	2			1	100	1	100		
	3	1	100			1	100		
Total		25	80.65	6	19.35	31	100		

TABLE 22 - Factors associated with Weaning failure: Group-C

Treatment Group		Weaning failure				Total		*Chi-square value*	*P-Value*
		No		Yes					
		N	%	N	%	N	%		
Number of criteria fulfilled	8	*7*	*77.78*	*2*	*22.22*	*9*	*100*	*4.927*	*0.085*
	9	*11*	*73.33*	*4*	*26.67*	*15*	*100*		
	7			*2*	*100*	*2*	*100*		
Sex	Male	*13*	*81.25*	*3*	*18.75*	*16*	*100*	*2.821*	*0.093*
	Female	*5*	*50.00*	*5*	*50.00*	*10*	*100*		
Diagnosis	Respiratory	*6*	*54.55*	*5*	*45.45*	*11*	*100*	*3.168*	*0.530*
	Cardiac	*1*	*100*			*1*	*100*		
	Neurological	*9*	*81.82*	*2*	*18.18*	*11*	*100*		
	Sepsis	*1*	*100*			*1*	*100*		
	Others	*1*	*50.00*	*1*	*50.00*	*2*	*100*		
Comorbidity	No	*11*	*73.33*	*4*	*26.67*	*15*	*100*	*0.280*	*0.597*
	Yes	*7*	*63.64*	*4*	*36.36*	*11*	*100*		
Shock	No	*8*	*80.00*	*2*	*20.00*	*10*	*100*	*0.885*	*0.347*
	Yes	*10*	*62.50*	*6*	*37.50*	*16*	*100*		
Inotropes	No	*9*	*75.00*	*3*	*25.00*	*12*	*100*	*0.348*	*0.555*
	Yes	*9*	*64.29*	*5*	*35.71*	*14*	*100*		
Nosocomial pneumonia	Yes	*4*	*66.67*	*2*	*33.33*	*6*	*100*	*0.024*	*0.877*
	No	*14*	*70.00*	*6*	*30.00*	*20*	*100*		
Number of trial	3	*5*	*62.50*	*3*	*37.50*	*8*	*100*	*3.115*	*0.374*
	4	*10*	*83.33*	*2*	*16.67*	*12*	*100*		
	5	*2*	*66.67*	*1*	*33.33*	*3*	*100*		
	6	*1*	*33.33*	*2*	*66.67*	*3*	*100*		
Number of trial failure	0	*14*	*100*			*14*	*100*	*14.432*	*0.002*
	1	*3*	*42.86*	*4*	*57.14*	*7*	*100*		
	2	*1*	*25.00*	*3*	*75.00*	*4*	*100*		
	3			*1*	*100*	*1*	*100*		
Total		*18*	*69.23*	*8*	*30.77*	*26*	*100*		

FACTORS ASSOCIATED WITH WEANING FAILURE

GROUP B: In group B, children who required more trials (P 0.009) for weaning & those who had more trial failures (P 0.021) had statistically significant weaning failure.

GROUP C: In group C, children who had more trial failures (P 0.002) had statistically significant weaning failure.

FINAL COMPARISON OF MAJOR OUTCOME VARIABLES

TABLE 23

	GROUP A	GROUP B	GROUP C	P – VALUE
WEANING FAILURE **N** **YES** **NO**	 31 1 30	 31 6 25	 26 8 18	0.021
NUMBER OF TRIALS (MEAN)	1.13 ± 0.061	3.27 ± 0.152	3.66 ± 0.214	0.000
DURATION OF WEANING (MEAN)	5.1 +/- 1.469	31.87 +/- 2.657	39.28 +/- 3.850	0.000

DISCUSSION

DISCUSSION

In this randomized control trial of comparing the three methods of weaning (T – piece trial , CPAP / PSV & SIMV) from mechanical ventilators in children aged 1 month to 12 years , the results were analysed using appropriate statistical tests. In our study weaning was successful as well as duration of weaning was shorter in T – Piece technique than the other two.

Intermittent Mandatory Ventilation

Several advantages have been claimed for intermittent mandatory ventilation as a weaning technique: it is supposed to prevent a patient from "fighting" the ventilator, reduce respiratory-muscle fatigue, and expedite weaning. However, there are few data to support these claims[24,26]Intermittent mandatory ventilation is usually delivered in a synchronized manner with demand- valve circuitry, which increases the work of breathing. The intermittent nature of assistance also poses a problem. It was previously assumed that the degree of respiratory-muscle rest was proportional to the level of machine assistance. However, recent evidence indicates that respiratory-sensor output does not adjust to breath-to-breath changes in respiratory load, and intermittent mandatory ventilation may therefore

contribute to the development of respiratory muscle fatigue or prevent recovery from it.

Studies of the efficacy of intermittent mandatory ventilation in weaning have serious limitations. Schachtern et al[44]. compared it with conventional ventilation & noted no difference between the two techniques in the duration of ventilator support. Their study suffers from a retrospective design nonuniform study groups, and inadequate description of the protocol. Esteban etal[24] compared it with single daily and multiple daily spontaneous breathing trials with t- piece and pressure ventilation and found SIMV as the poorest method of weaning. On comparison with single daily T – piece trial P value was < 0.006. In our study P value was 0.000.

Pressure-Support Ventilation

Pressure-support ventilation is commonly used to counteract the work of breathing imposed by endotracheal tubes and ventilator circuits. Theoretically, this should help with weaning, because a patient who is comfortable at the compensatory level of pressure support should be able to sustain ventilation after extubation. However, the level of pressure support necessary to eliminate the work imposed by endotracheal tubes and ventilator circuits varies considerably (from 3 to 14 cm of water); thus, any

prediction of a patient's ability to sustain ventilation after extubation is likely to be misleading[24-26].

Brochard et al [25]. recently reported that the duration of weaning was significantly shorter with pressure support (5.7 - 3.7 days) than with intermittent mandatory ventilation (9.9 - 8.2 days) or trials of spontaneous breathing (8.5 - 8.3 days). This is in contrast to the findings in our study where the duration of weaning was shortest with T – piece trial (mean 5.1 hrs) as compared with CPAP / PSV (mean 31.87 hrs) and SIMV (39.28 hrs) with a P value of 0.000. Results of study conducted by Esteban etal where the median duration of weaning was 5 days for intermittent mandatory ventilation (first quartile, 3 days; third quartile, 11 days), 4 days for pressure-support ventilation (2 and 12 days, respectively), 3 days for intermittent (multiple) trials of spontaneous breathing (2 and 6 days, respectively), and 3 days for a once-daily trial of spontaneous breathing (1 and 6 days, respectively) were similar to that in our study.

T piece trial of spontaneous breathing

A once-daily trial of spontaneous breathing also allowed speedier weaning than approaches offering partial ventilatory support. This approach simplifies management, since a patient's ability to breathe spontaneously without ventilatory support needs to be assessed only once a day. In contrast,

with intermittent mandatory ventilation and pressure-support ventilation, ventilator settings must be adjusted repeatedly and each adjustment is usually followed by an arterial-blood gas measurement [30,31].

An implied goal of the various weaning techniques is to recondition respiratory muscles that may have been weakened during the period of mechanical ventilation. Theoretically, a once-daily trial of spontaneous breathing and a prolonged period of rest may be the most effective method of eliciting adaptive changes. This approach meets the three principal requirements of a conditioning program: overload, specificity, and reversibility. During the trial, patients breathe against an elevated intrinsic load, thus satisfying the overload requirement[35]. Specificity is also satisfied, in that the trial is an endurance stimulus and the desired objective is enhanced endurance. Finally, the use of a daily trial prevents regression of the adaptive changes. It must be emphasized that this reasoning is based on indirect evidence and that the effect of different weaning techniques on respiratory-muscle reconditioning has not been investigated [35].

In our study T – piece trial was found to be superior in successful weaning (30 out of 31 P value 0.021) as well as shorter duration of weaning (mean of 5.1 hrs P value of 0.000) . This is similar to findings of Esteban et al where weaning was successful with T piece trial as compared

with pressure support ($p < 0.04$) and intermittent mandatory ventilation ($P < 0.006$).

Comparison of this study with others

	Esteban etal	**Brochard etal**	**Esteban etal**	**Jones etal**	**Our study**
Compared	IMV PSV Single daily T piece Multiple daily T piece	SIMV PSV T piece	PSV T piece	CPAP T piece	SIMV CPAP/PSV T piece
No. of patients	130	109	484	106	88
Weaning success	Once daily T piece	PSV	equal	equal	T piece
Duration of weaning	IMV – 5 days PSV - 4 days Single daily T piece & Multiple daily T piece – 3 days	Shorter with PSV	-	-	SIMV – 39.2 hrs CPAP/PSV – 31.8 hrs T piece – 5.1 hrs
P value	<0.006	<0.025	0.14	-	0.000

SUMMARY AND CONCLUSION

A randomized trial of comparing three methods of weaning from mechanical ventilators was completed in 88 children.

From this study we conclude that,

- Spontaneous extubation during weaning was least with T – piece trial.
- Duration of weaning & number of trials needed for weaning was least with T - piece trial.
- Weaning was ~ 6 times faster with T – piece than with CPAP/PSV and ~ 8 times faster than with SIMV.
- Weaning success was also highest with T – piece trial.
- Duration of weaning was not significantly different between CPAP/PSV & SIMV group
- T – piece trial as a technique for weaning of children from mechanical ventilators is the best as far as duration and success of weaning is concerned. This is independent of age or sex or etiology or duration of ventilation prior to weaning or presence of shock or use of inotropes or the underlying disease process.

ANNEXURE 1

DATE

NAME: AGE/SEX: IP.NO

S.NO	WEANING CRITERIA (7 0ut of 9)	YES	NO
1	Etiology improving		
2	Alert mental status / GCS > = 11		
3	Good cough / gag reflex		
4	Temperature < 38.5 degree Celsius		
5	No clinical need for increase in ventilatory support in past 24 hours		
6	Hemodynamic stability - CRT< 3 sec - HR normal range for age* - Systolic BP normal range for age* - No further need for vasoactive agents		
7	Parameters of oxygenation - SPO2 of > 94% on FiO2 of <= 0.5 - PIP < 20cms/ h20 - PEEP <= 5		
8	No acidosis - pH of 7.32 – 7.47 - pCO2 < 50mm/Hg		
9	Respiratory rate in acceptable range < 6 months 20 – 60 / min 6m to 2 yrs 15 – 45 / min 2 to 5 yrs 15 – 40 / min > 5 yrs 10 – 35 / min		

*

AGE	HEART RATE(HR) rates/min	SYSTOLIC BP mm/Hg
< 6 months	90 – 180	50 – 70
6 months	85 – 170	65 – 106
1 year	80 – 140	72 – 110
3 year	80 – 130	78 – 114
6 year	70 – 120	80 – 116
8 year	70 – 110	84 – 122
10 year	65 – 110	90 – 130
12 year	60 – 110	94 – 136

IF CRITERIA FULFILLED: RANDOM NUMBER - GROUP –

ANNEXURE 2

DATE

NAME: AGE/SEX: IP.NO

RANDOM NUMBER - GROUP –

TRIAL NO	STARTING TIME	ENDING TIME

GROUP	TRIAL	SETTINGS	
A	T- piece		
B	CPAP/PSV	PEEP	PS
C	SIMV	RATE/MIN	

CRITERIA TO STOP SPONTANEOUS BREATHING TRIAL

CRITERIA(yes to any 1 criteria)	yes	no
Inability to maintain gas exchange - SPO2 < 95% with FiO2 of 0.4		
Inability to maintain effective ventilation - PCO2 of > 50 mm/Hg or increase of > 10mm/Hg from previous value - pH < 7.3		
Increased work of breathing - Respiratory rate in acceptable range < 6 months 20 – 60 / min 6m to 2 yrs 15 – 45 / min 2 to 5 yrs 15 – 40 / min > 5 yrs 10 – 35 / min - increased use of accessory muscles of respiration - paradoxical breathing		
Signs of distress - diaphoresis - anxiety - change in mental status(agitation/somnolence) - BP – hyper/ hypo tension - Heart rate – Brady/ tachy cardia		

TRIAL OUTCOME – SUCCESS / FAILURE

EXTUBATION TIME –

REFERENCE

1. Scarpelli EM, Auld PAM, Goldman AS. Pulmonary Disease of the Fetus. Newborn and Child. Philadelphia, Lea and Febiger, 1978; pp 1309 -1311.

2. Steven JM, Raphaely RC, Edmunds H Jr, Downes JJ. Respiratory support in infants. In: Surgery of the Chest, 6th edn. Eds. Sabiston DC, Spencer FC. Philadelphia, W.B. Saunders, 1995; pp 347-367.

3. Macdonald KD, Johnson SR. Volume and pressure modes of mechanical ventilation in pediatric patients. Respir Care Clin N Am 1996; 2: 607-618.

4. Kirby RR, Banner MJ, Lampotang S, Blanch PB. Mechanical Ventilation. In: Critical Care, 3rd edn. Eds. Civetta JM, Taylor RW, Kirby RR, Philadelphia, Lippincott Raen, 1996, pp 719-734.

5. Task Force on Guidelines. Society of Critical Care Medicine, Guidelines for Standards of Care for Ventilatory Support. Crit Care Med 1991; 19: 275-278.

6. Kanter RK, Blatt SD, Zimmerman JJ. Initial mechanical ventilator settings for pediatric patients. Am J Emerg Med 1987; 5: 113-117.

7. Chalon J, Loew DA, Malebranche J. Effects of dry anesthetic gases on tracheobronchial and ciliated epithelium. Anesthesiology 1972; 37: 338-343.

8. Khilnani P, Chugh K. Mechanical ventilation in pediatrics. In: Manual of

Pediatric Inten-sive Care. Eds. Chugh K, Khilnani P, Sachdev A, Saluja S. New Delhi, Indian Academy of Pediatrics, 1993; pp 42-72.

9. Nicholas S. Hill, Mitchell M. Levy. Ventilator Management Strategies for Critical Care . critical care 1998 ; 7 : 250 – 252.

10. MacIntyre NR. Issues in ventilator weaning. Chest 1999; 155: 1215-1216.

11. Hall JB. Wood LDH. Liberation of the patient from mechanical ventilation. JAMA 1987; 257: 1621-1628.

12. Farias JA, Alia I, Esteban A, Golubicki AN, Olazarri FA. Weaning from mechanical ventilation in pediatric intensive care patients. Intensive Care Med 1998; 24: 1070-1075.

13. Khan, N., A. Brown, and S. T. Venkataraman. 1996. Predictors of extubation success and failure in mechanically ventilated infants and children. *Crit. Care Med.* 24:1568–1579.

14. Baumeister, B. L., M. El-Khatib, P. G. Smith, and J. L. Blumer.1997. Evaluation of predictors of weaning from mechanical ventilation in pediatric patients. *Pediatr. Pulmonol.* 24:344–352.

15. Tobin, M. J., W. Perez, S. M. Guenther, B. J. Semmes, M. J. Mador, S. J. Allen, R. F. Lodato, and D. R. Dantzker. 1986. The pattern of breathing during successful and unsuccessful trials of weaning from

mechanicalventilation. *Am. Rev. Respir. Dis.* 134:1111–1118.

16. Balsan, M. J., J. G. Jones, J. F. Watchko, and R. D. Guthrie. 1990. Measurements of pulmonary mechanics prior to elective extubation of neonates. *Pediatr. Pulmonol.* 9:238–243.

17. Epstein SK, Ciubotaru RL. Independent effects of etiology of failure and time to reintubation on outcome for patients failing extubation. *Am J Respir Crit Care Med* 1998;158:489-93.

18. Ely EW, Baker AM, Dunagan DP, *et al*: Effect on the duration of mechanical ventilation of identifying patients capable of breathing spontaneously. *N Engl J Med* 1996, 335:1864–1869.

19. Yang KL, Tobin MJ: A prospective study of indexes predicting the outcome of trials of weaning from mechanical ventilation. *N Engl J Med* 1991, 324:1445–1450.

20. Sassoon CSH, Mahutte CK: Airway occlusion pressure and breathing pattern as predictors of weaning outcome. *Am Rev Respir Dis* 1993, 148:860–866.

21. Jabour ER, Rabil DM, Truwit JD, Rochester DF: Evaluation of a new weaning index based on ventilatory endurance and the efficiency of gas exchange. *Am Rev Respir Dis* 1991, 144:531–537.

22. Levy MM, Miyasaki A, Langston D: Work of breathing as a weaning

parameter in mechanically ventilated patients. *Chest* 1995, 108:1018–1020.

23. BILL PRUITT, RRT, AE-C, CPFT, MBA. Weaning patients from mechanical ventilation. Nursing2006, Volume 36, Number 9 ; 38

24. Esteban A, Frutos F, Tobin MJ, *et al*: A comparison of four methods of weaning patients from mechanical ventilation**.** *N Engl J Med* 1995, 332:345–350.

25. Brochard L, Rauss A, Benito S, *et al*: Comparison of three methods of gradual withdrawal from ventilatory support during weaning from mechanical ventilation. *Am J Respir Crit Care Med* 1994, 150: 896–903.

26. Esteban A, Alía I, Gordo F, *et al*: Extubation outcome after spontaneous breathing trials with T-tube or pressure support ventilation. *Am J Respir Crit Care Med* 1997, 156:459–465.

27. Esteban A, Alía I, Tobin MJ, *et al*: Effect of spontaneous breathing trial duration on outcome of attempts to discontinue mechanical ventilation. *Am J Respir Crit Care Med* 1999, 159:512–518.

28. Jaeschke R, Guyatt GH, Sackett DL, for the Evidence-Based Medicine Working Group: How to use an article about a diagnostic test. What are the results and will they help me in caring from my patient? *JAMA* 1994, 271:703–707.

29. Reyes A, Vega G, Blancas R, *et al*: Early vs conventional extubation

after cardiac surgery . *Chest* 1997,112:193– 201.

30. Vallverdú I, Calaf N, Subirana M, *et al*: Clinical characteristics, respiratory functional parameters, and outcome of a two-hour T-piece trial in patients weaning from mechanical ventilation. *Am J Respir Crit Care Med* 1998, 158:1855–1862.

31. Jones DP, Byrne P, Morgan C, Fraser I, Hyland R: Positive end expiratory pressure vs T-piece. Extubation after mechanical ventilation. *Chest* 1991, 100:1655–1659.

32. Jacob B, Chatila W, Manthous CA: The unassisted respiratory rate/tidal volume ratio accurately predicts weaning outcome in postoperative patients. *Crit Care Med* 1997, 25:253–257.

33. Krieger BP, Isber J, Breitenbucher A, Throop G, Ershowsky P: Serial measurements of the rapid-shallow-breathing index as a predictor of weaning outcome in elderly medical patients. *Chest* 1997,112:1029–1034.

34. Petrof BJ, Legaré M, Goldberg P, Milic-Emili J, Gottfried SB: Continuous positive airway pressure reduces work of breathing and dyspnea during weaning from mechanical ventilation in severe chronic obstructive pulmonary disease. *Am Rev Respir Dis* 1990, 141:281–289.

35. MacIntyre NR, Cheng KC, McConnell R: Applied PEEP during pressure support reduces the inspiratory threshold load of intrinsic PEEP. *Chest* 1997,

111:188–193.

36. Sydow M, Golisch W, Buscher H, *et al*: Effect of low-level PEEP on inspiratory work of breathing in intubated patients, both with healthy lungs and with COPD. *Intens Care Med* 1995, 21:887–895.

37. Ranieri VM, Guliani R, Cinnella G, *et al*: Physiologic effects of positive end-expiratory pressure in patients with chronic obstructive pulmonary disease during acute ventilatory failure and controlled mechanical ventilation. *Am Rev Respir Dis* 1993, 147:5–13.

38. Cohen CA, Zagelbaum C, Gross D, Roussos Ch, Macklem PT: Clinical manifestation of inspiratory muscle fatigue. *Am J Med* 1982, 73:308–316.

39. Brochard L, Harf A, Lorino H, Lemaire F: Inspiratory pressure support prevents diaphragmatic fatigue during weaning from mechanical ventilation. *Am Rev Respir Dis* 1989, 139:513–521.

40. Laghi F, D'Alfonso N, Tobin MJ: Pattern of recovery from diaphragmatic fatigue over 24 hours. *J Appl Physiol* 1995, 79:539–546.

41. Slutsky AS: ACCP Consensus Conference: mechanical ventilation. *Chest* 1993, 104:1833–1859.

42. Marini J, Rodriguez R, Lamb V: The inspiratory workload of patient initiated mechanical ventilation. *Am Rev Respir Dis* 1986, 134: 902–909.

43. D P Jones, P Byrne, C Morgan, I Fraser and R Hyland. Positive end-

expiratory pressure vs T-piece extubation after mechanical ventilation. *Chest* 1991;100;1655-1659

44. Schachter EN, Tucker D, Beck GJ. Does intermittent mandatory ventilation accelerate weaning? JAMA 1981;246:1210-14.